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ABSTRACT

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# COST AND EFFECTIVENESS OF COMPUTER BASED TRAINING

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## Abstract

The methodology and results of cost-effectiveness evaluations of computer based instruction used in military training are discussed. Methodological issues center on decisions about what cost elements and what effectiveness measures should be included and how they should be combined. Preliminary results suggest that, in general, computer based instruction costs about .28 less per unit of effectiveness than do conventional approaches to instruction.

## Introduction

As managers, developers, and users of computer-based instruction (CBI) become increasingly familiar with the medium, the questions they ask about its value correspondingly increase in sophistication. Specifically, they are beginning to ask if the costs of CBI repay its users with commensurately increased effectiveness, or, in short, is CBI a cost-effective alternative for training?

Computers have been used in training since the late 1950s. Evaluations of their effectiveness have not received high priority. Instead the emphasis has been on developing and implementing successive generations of intuitively appealing approaches rather than systematically assessing the ones that are already in hand. After 25 years of experience, however, considerable test and evaluation data have been accumulated. Cost data have been accumulating even more slowly than effectiveness data, but some are now available and credible analyses of CBI cost-effectiveness are now attainable.

This paper provides an in-process review of an effort to update earlier studies of CBI cost-effectiveness in military training. The paper addresses five topics: (1) the differences between education and training and why they matter; (2) findings of earlier studies on the cost-effectiveness of CBI; (3) methodological issues uncovered by these earlier studies; (4) preliminary results from our current studies; (5) some discussion of what we need to do next.

## Education Versus Training

There are differences, primarily in emphasis, between education, with which most of us who went to school are familiar, and training, which is the concern of the Department of Defense and substantial portions of industry. Most important among these differences are: (1) training objectives are driven by the requirements of specific jobs, those of education key on more general, less well defined goals, and (2) whereas education can be viewed as a positive end in its own right, training is a means to an end. Again, training and education are distinguished by what they emphasize, not by well-defined thresholds of demarcation. Most training contains elements of education, and most education involves some training. Education prepares people for training, and training motivates education.

However, the differences influence the methodology of cost-effectiveness evaluations. In training, we are usually trying to achieve some threshold(s) of effectiveness, so our evaluations hold effectiveness constant and look for cost reductions in obtaining it. We want to know how much it costs to obtain a unit of effectiveness. In education, we are usually trying to maximize effectiveness, so our evaluations tend to hold costs constant and look for ways to maximize effectiveness given these costs. We want to know how much effectiveness we obtain from a unit of cost.

Military training in the United States is a substantial enterprise. In FY 1988, the Services will spend more than $18 billion to support the 210,000 active duty personnel and the 45,000 reservists and guardsmen who will be in formal training each day of the year [1]. These figures exclude the funding and people involved in job-site training, factory and unit training for new systems, organized team training for performance of specific missions, and all field exercises. Precise figures on the magnitude of these activities are not available, but they would likely increase the $18 billion figure by a factor of three or four. The impact of cost-effective approaches such as those promised by CBI is proportionately large and of considerable interest.

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The term computer based instruction (CBI) is a general term that usually refers to all uses of computers in education and training. Among other things, it covers the combination of computer managed instruction (CMI), which is used to allocate instructional resources, guide student progress, and keep records, and computer assisted instruction (CAI), which concerns the direct use of computers to teach. In short, the results reported here concern CMI, CAI, and their combination, CBI.

## CBI Effectiveness

About six 'meta-analyses', or reviews of research on the effectiveness of CBI have been completed. These have all shown CBI to be effective. Probably the earliest systematic review was published in 1972 by Vinsonhaler and Bass [2]. It covered 34 published, empirical evaluations of CAI drill and practice involving over 10,000 different students. It found positive results in 30 of the 34 studies and a median increase in student achievement of 40%. More recent reviews of CBI in education by Kulik, Bangert, and Williams [3] and by Kulik, Kulik, and Bangert [4] found similar results. These reviews are worth mentioning here, but only that since the topic is CBI in military training.

The principal review of CBI effectiveness in military training was published by Orlansky and String in 1979 [5]. It found positive results in 44 of 48 studies with a median student training time savings of 32% and equivalent or superior student achievement in 47 of the 48 studies. If student time is a sufficient measure of cost -- and military students are paid while they are trained -- we might conclude from this review that CBI is a cost effective alternative to conventional instruction. However, three issues, at least, should be raised. First, student time may not suffice as a measure of cost. Second, end of course achievement may not suffice as a measure of achievement. Third, many of these studies do not provide a clear comparison of CBI with conventional instruction. These issues and others are considered in the following comments.

## Methodological Issues

### Costs

Student time savings are more substantive than they appear on the surface. Despite considerable reductions in training costs, instructor costs, wear and tear on materiel, and student salary costs, the most significant cost avoidances represented by student time savings may be in manpower costs as Solomon has recently pointed out [6]. He used some simple numerical examples to show that shorter training times mean that fewer people need to be brought into the military -- and that fewer people means major cost advoidances.

On the other hand, student time is only one element of training costs. Knapp and Orlansky [7] developed a fairly complete costing structure for military training. They used the standard cost categories of research and development, initial investment, and operations and support. Their model includes 11 research and development, 25 initial investment, and 39 operations and support cost elements -- a total of 75 cost elements of which student pay and allowances is only one. Earlier cost structures have been developed for military training [8], and they are packed with equivalent numbers of cost elements.

There are, then, many elements of cost that can be considered in cost-effectiveness evaluations. Which elements to include in any study is a difficult and significant decision. The results reported later in this paper are based on operating and support costs only, but these costs have been aggregated in the reports from which they are drawn. The specific cost elements on which they are based are generally unknown.

### Effectiveness

Training effectiveness evaluations usually consider only one or two outcomes of training. However, there are likely to be several intended outcomes of any training program. These may include outcomes such as speed of response, accuracy of response, transfer of training, motivation and interest, insight, and long term retention. Effectiveness measures, like cost measures, must be selected from a list of possibilities depending on the objectives of those providing the training. Many evaluation studies fail to reflect relevant training objectives in the effectiveness measures they use.

Moreover, the primary objective of military training is combat effectiveness. Measures of this outcome are (fortunately) rare and hard to come by. However, it should be noted that underlying all military training is an objective that is difficult to measure, often neglected, and absolutely fundamental.

### Existing Comparisons

Many of the studies designed to investigate the costs and effectiveness of CBI involve three steps: (1) instructional systems design "clean up" of the original course; (2) individualization of the resulting course; (3) comparison of CBI presentation of the resulting cleaned up and individualized course with the original version. In other words, they are not straight-forward comparisons of CBI with conventional presentations of the same course.

On the other hand, a "real" comparison might unnecessarily handicap CBI, since the training would have to be reduced to the lowest common denominator (i.e., the conventional version) to provide common ground for the comparison and would fail to take advantage of the instructional power available in CBI. The "head to head" comparison of CBI with conventional instruction may be both unavailable and unenlightening.

Nonetheless, taking a set of training objectives and simply trying to meet them with conventional means and with CBI, may, at a general level, provide adequate comparisons for managers to decide whether or not to invest in computer based instruction. These are the sort of comparisons we have sought in our current review of CBI costs and effectiveness.

## Measures of Cost Effectiveness

Once we have measures of both costs and effectiveness, we must decide what to do with them. Our current approach is based on ratios. Costs are compared as a ratio of costs for one training approach to another. Effectiveness is also compared as a ratio of the effectiveness of one approach to another. Cost-effectiveness is treated as a ratio of ratios -- the cost ratio over the effectiveness ratio. It can be interpreted, roughly, as the cost to obtain a unit of effectiveness. CBI comparisons are usually arranged so that a cost effectiveness ratio of 1.00 means that CBI and the conventional training alternative are equivalent from a cost effectiveness standpoint, and the lower the cost-effectiveness ratio, the more cost-effective CBI is as a training alternative.

These ratios are intended to provide measures that: (1) by themselves indicate which of two compared approaches is the most cost-effective; (2) can be used to map various approaches onto an interval scale; (3) are defined so that lesser effectiveness can be compensated for by lower cost and conversely; (4) are roughly commensurable so that we can estimate the cost-effectiveness of different approaches by comparing these ratios with one another; and (5) are simple to compute and interpret. These specifications may be satisfied by the cost-effectiveness ratios we use.

## Preliminary Results

In updating the earlier studies, we reviewed about 400 evaluations of military training to identify a subset of about 80 that report both cost and effectiveness data. The following preliminary results are based on 18 of these studies, and they probably represent about a third of the full set of studies that we will eventually use. However, it appears unlikely that the final report will make any dramatic departures from the conclusions reported here.

The Services also contrast maintenance with operator instruction. The purpose of these types of instruction is evident from their names. Maintenance instruction concerns the training of people to be maintenance technicians, and operator instruction concerns the training of people to operate military systems, which can range from radios and rifles to tanks and aircraft. Three of our findings concern the relative cost-effectiveness of CBI for operator and maintenance training.

The results of our analyses thus far can be summarized in seven statements:

1. CAI costs about .33 less per unit of effectiveness than does conventional instruction.

2. CMI costs about .24 less per unit of effectiveness than does conventional instruction.

3. CAI costs about .09 less per unit of effectiveness than does CMI.

4. CBI costs about .30 less per unit of effectiveness than does conventional maintenance instruction.

5. CBI costs about .27 less per unit of effectiveness than does conventional operator instruction.

6. CBI for maintenance instruction costs about .03 less per unit of effectiveness than does CBI used for operator instruction.

7. CBI costs about .28 less per unit of effectiveness than does conventional instruction.

## What Next?

We expect minor, but not major shifts in our results. What you see here is what we expect to get. However:

1. The costs considered here are known to be operation and support costs, but what specific cost elements among those concerned with operations and support were used is at best uncertain. There needs to be an agreed-upon, minimal set of cost elements that studies could realistically be expected to extract and use to estimate the cost-effectiveness of CBI -- and any other training approach.

2. The effectiveness measures considered here concern end of training performance and not on the job performance. There are serious problems in measuring on the job performance, but training offers an opportunity and a tight feedback loop for comparing training system design with attainment of specific training outcomes. Using systematic, data-based procedures to determine how to design training to bring about specific outcomes would benefit not only training but education as well.

3. Few of these results are based on third party evaluations. Most of them were obtained by the same people who developed or implemented the CBI in the first place. We need a program to generate more objective evaluation data.

4. Many of these results are based on prototype CBI applications. Once CBI is implemented in a post-experimental setting, its evaluation is generally neglected. We need information from stable, non-experimental settings if we are to advance the state of the art beyond the 'gee-whiz' stage.

After all these caveats, however, the results presented above may represent the best information we have on the costs and effectiveness of CBI in military training. They are not conclusive, but they are favorable and support decisions to further develop CBI for training applications.

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